INST. EP
LIBRARY
E & A

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1655

The Control of Moths in Upholstered Furniture

1931

THE RUINATION of woolen covers of upholstered furniture by moths is a source of great concern and loss throughout the United States. This bulletin is intended to acquaint the reader with essential facts favoring the development and control of moths as pests of upholstered furniture, so that he may guard against attack by them, which in too many instances is of such an insidious nature that the aesthetic value of furniture covers is destroyed even before the owner suspects the presence of insects. There seems to be no reason why woolen covers can not be maintained in good condition indefinitely, so far as moths are concerned, if owners will intelligently follow the suggestions for control discussed in this bulletin.

Washington, D. C. Issued February, 1931

cat. fr. Sep.

THE CONTROL OF MOTHS IN UPHOLSTERED FURNITURE

J.R.R.

By E. A. Back, *Principal Entomologist, in charge, and* R. T. Cotton, *Senior Entomologist, Stored-Product Insect Investigations, Bureau of Entomology*

CONTENTS

	Page
Injury to furniture widespread	1
The two kinds of moths responsible for the injury	1
Brief summary of biology	3
The adult	3
The egg	6
The larva or worm	6
The pupa	6
Duration of development	8
The food of clothes moths	10
Normal food	10
Materials not used as food	11
The food of clothes moths—Continued.	
The parts of upholstered furniture eaten by moth larvae	11
Immunity of vegetable materials used for upholstering	12
How moths get into furniture	12
Two methods of attack upon woolen covers	16
Surface feeding	16
Feeding from below the cover	16
Control	23
Preventive measures	23
Remedial measures	26

INJURY TO FURNITURE WIDESPREAD

INJURY CAUSED by the infestation of upholstered furniture by moths is widespread. (Figs. 1, 2, and 3.) No section of the country seems free from such infestations. Most of the losses sustained are due to neglect, or to a lack of information concerning the life history and habits of the moths. Frequently these insects are discovered too late to prevent some defacement of the covers of the furniture.

Injury by moths is confined almost entirely to pieces of furniture having covers containing wool, such as wool tapestries and mohairs. The present popularity of these covers, because of their beauty and durability, need not be lessened because of the moth problem. Reputable furniture manufacturers and retailers, and storage concerns, have already gone to much expense to eliminate moths in furniture and to provide protection against infestation by them. If the housewife were as well informed a large share of the present-day losses could be prevented.

THE TWO KINDS OF MOTHS RESPONSIBLE FOR THE INJURY

There are two kinds, or species, of moths found more commonly in upholstered furniture in the United States. They are the two species of clothes moths known for generations as household pests—the webbing clothes moth (*Tineola biselliella* Hummel) and the case-making clothes moth (*Tinea pellionella* L.). One or the other, or both, are present in practically every household. Most housewives are already familiar with them as pests of clothing, rugs, piano felts, and other woolen fabrics.

The moths of both species are small, buff-colored millers, with a wing spread of about one-half inch. They seldom fly directly to a light in a room, and remain flitting about it, as do so many moths both small and large which develop on outdoor vegetation, and for which a light has a great attraction. Clothes moths are usually seen flying in darkened corners and just beyond the range of the brightest rays of the lamp. They prefer darkness. They have imperfectly developed mouth parts, and could not feed upon fabrics if they wished. Their sole purpose in life is to lay eggs that develop into the worms, or larvae, which alone can cause destruction. The larvae

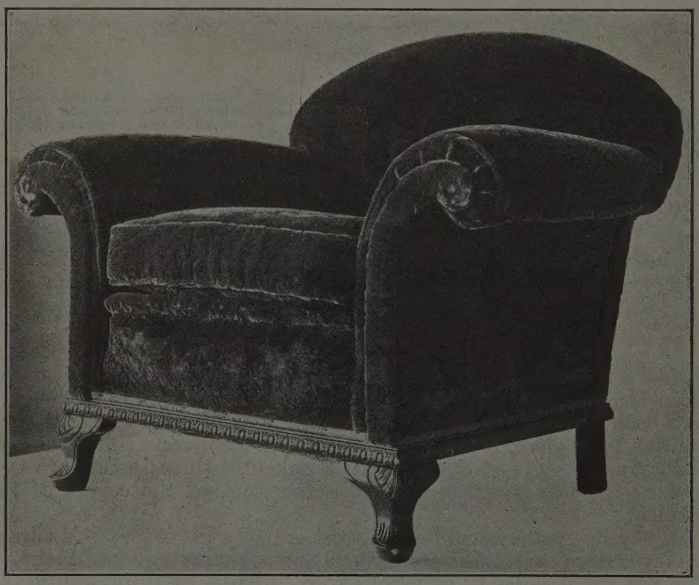

FIGURE 1.—Mohair-covered chair, showing bare spots developing in cover along the lower part of the side and in front beneath the cushion. On examination it was found that in front there was nothing between the cover and the framework but Spanish moss. Observe how general the damage is at this point. At the side the injury is always greatest low down, where the moths congregate in largest numbers between the cover and the framework, and where there is no cotton. The open spaces above, between the cover and the framework, form an excellent flying space for moths

hatching from the eggs are, when fully grown, whitish and about half an inch long. They spin cocoons, and in these they transform to the pupa, or chrysalis, stage. During this stage the insect changes to the adult, or moth. Thus each generation of clothes moths passes through four distinct stages, namely, the egg (figs. 4 and 6), the larva or worm (figs. 5, 7, 8, 9, 10, 11, 12, 22, 24, and 25), the pupa or chrysalis (fig. 10), and the adult or moth (figs. 4, 5, 11, and 22). The reader should examine each illustration just referred to and read the accompanying legends for additional information regarding the general appearance of the different forms of the clothes moth.

BRIEF SUMMARY OF BIOLOGY

The biology of the two clothes moths affecting upholstered furniture is much the same. The following facts are taken from data obtained by the writers in their study of the webbing species.

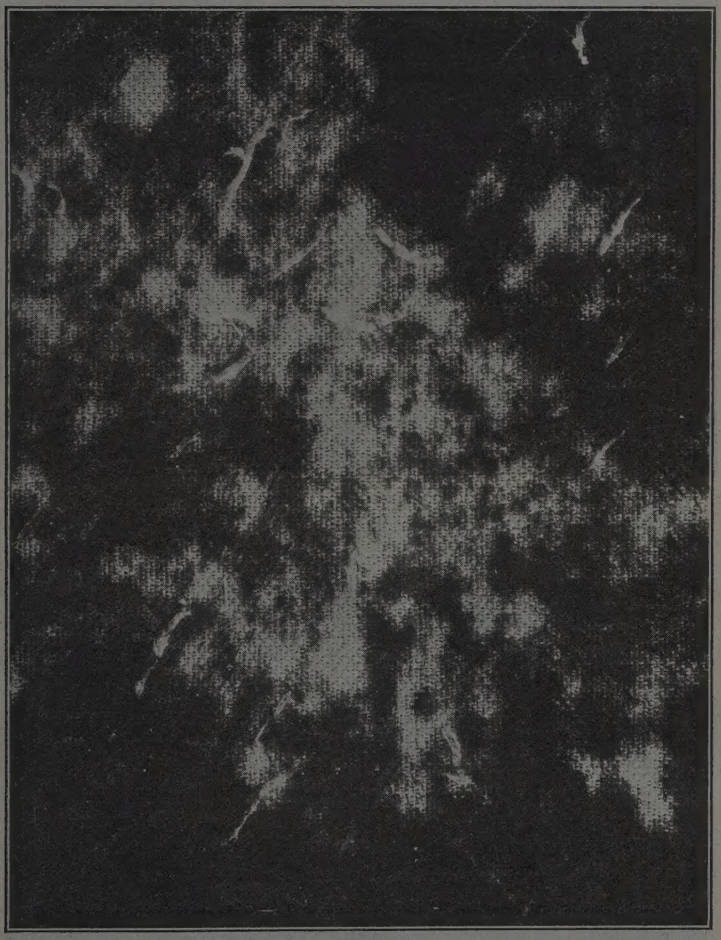

FIGURE 2.—Piece of mohair, showing, about natural size, a typical case of general surface feeding by clothes-moth larvae. Observe the scattering of moth webs

THE ADULT

The moth, or miller (figs. 4, 5, and 11), as it is often called, is the parent insect. It does not grow in size, and, as has been stated, its only function in life is reproduction. Within a few hours after leaving the cocoon and after mating, the female moth begins to lay

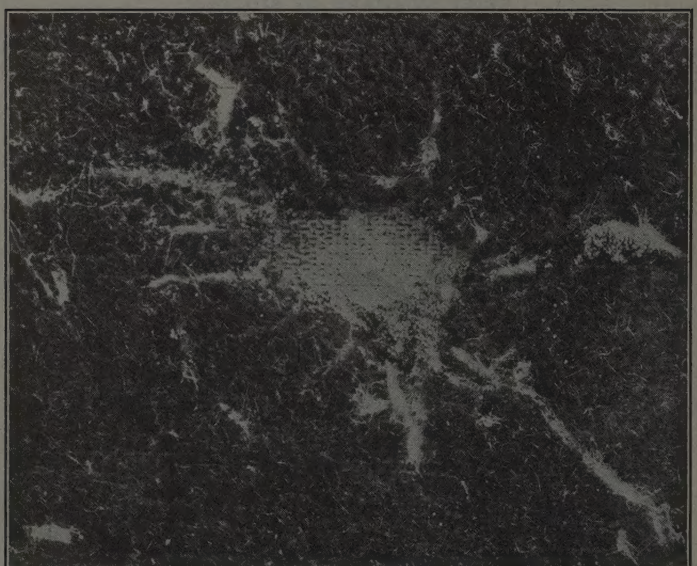

FIGURE 3.—Soiled spot on mohair cover, upon which moth larvae have concentrated their attack. An excellent illustration of surface feeding (p. 16), as indicated by the white feeding tubes or webs of the larvae which center on the soiled spot, the pile over which has been entirely eaten out. × 1½

FIGURE 4.—Female webbing clothes moth, enlarged 6 diameters. Observe particularly the two white eggs that she has just laid in the nap of the fabric upon which she is resting. She can place eggs down in the nap or the pile and crevices of furniture by means of her ovipositor, which can be extended much as can an old-fashioned, extensible telescope. The ovipositor, partly extended, is shown at the tip of her body

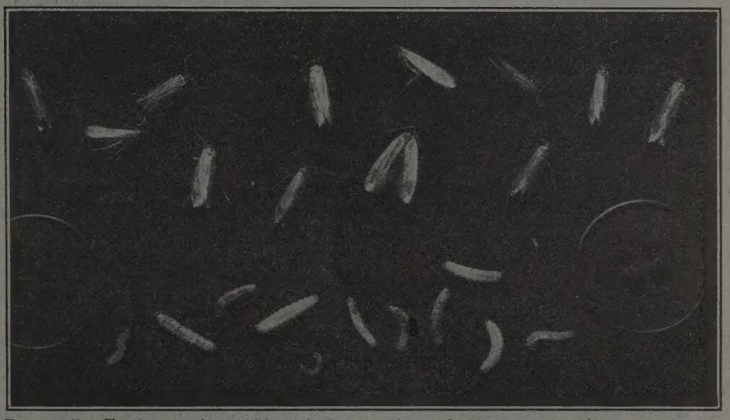

FIGURE 5.—Twelve adult webbing clothes moths and 11 worms, or larvae. All are photographed on a vest, the buttons of which are nine-sixteenths of an inch in diameter. Enlarged 1⅛ diameters

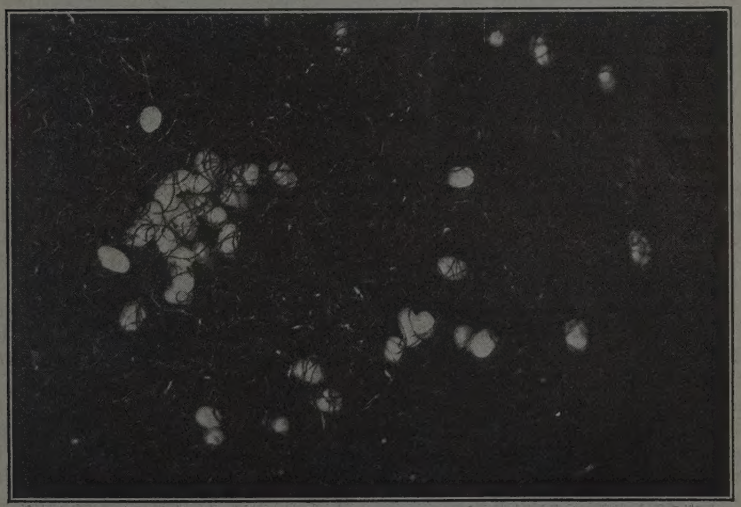

FIGURE 6.—Eggs of the webbing clothes moth, laid on a woolen cloth. They are hardly as large as the head of an ordinary pin, white, fragile, easily crushed by brushing. Although not glued to the fabric, many are laid well down in the nap, from which they can not be easily shaken. Enlarged 6 diameters

eggs. Although females may live for 30 or 40 days, most of them have a life of 10 to 14 days. Each female moth may lay a total of 200 to 300 eggs, although 100 eggs seems a more usual number. One moth laid 59 eggs in one day, but this number is above the average. The following three egg-laying records are taken as typical for warm weather when moths are kept in confinement; A female, emerging from her cocoon on August 2, laid 28, 12, 23, 5, and 2 eggs on August 3, 4, 5–6, 7, and 8, respectively. Another, emerging on August 1, laid 1, 28, 20, 31, 8, 5, and 1 eggs on August 2, 3, 4, 5–6, 7, 8, and 10, respectively. A third female, emerging August 7, laid 16, 15, 6, 3, 5, 6, 6, 3, and 2 eggs on August 8, 9, 10, 11, 12, 13, 14, 15, and 16, respectively. When a female ceases to lay eggs, her death follows, as a rule, within one or two days.

THE EGG

The whitish, soft, and very fragile eggs (figs. 4, 6, and 18) hatch most readily in warm summer weather in from four to eight days. During colder weather hatching may not take place for three weeks. In well-heated buildings hatching does not require a much longer time than in warm summer weather. Eggs do not lie dormant and undeveloped through long periods of cold weather, as is supposed by some persons. If they do not hatch in a reasonably short time the embryo dies.

THE LARVA OR WORM

Of all the stages, the larva—the only stage in which clothes moths damage fabrics—is the most susceptible to outside influences upon its growth. The nature of its food, the temperature, and the humidity, all have pronounced effects. Sometimes, for no apparent reason, the larva may pass into a period of dormancy lasting some months, during which it will neither feed nor appreciably move about, but later it becomes active, feeds, and continues its growth.

When the semitransparent larva (fig. 7) leaves the egg it is scarcely one-sixteenth of an inch long; yet it begins at once to feed and to grow. It is then so transparent that the color of its food shows through its body as a line extending along the center. When fully grown (figs. 5 and 8) it is opaque, white, and may be as much as half an inch long, although its size will vary with its environment and food supply. It is not possible to judge the age of a larva by its size, for some larvae at 15 months of age are very much smaller than others only 2 months old. The great variation in the length of time larvae require to become well developed is one of the peculiar things about clothes moths. The shortest definite time for development recorded by the writers is about 40 days, at a temperature of 85° F. This is probably about the shortest time in which the larva can become full grown under favorable summer conditions of warmth and humidity. From this minimum the period of growth may be greatly extended, even to include several years, as is indicated by the facts given under the heading "Duration of Development" (p. 8).

THE PUPA

The pupal or chrysalis stage (fig. 10) is usually of short duration, lasting from about 8 to 10 days in summer to 4 weeks in winter, in

FIGURE 7.—Six newly hatched larvae of the webbing clothes moth, magnified 25 diameters. Observe four eggshells, appearing distinctly. The eggshells are transparent, and are very difficult to locate except with a microscope. The newly hatched larvae are about one-sixteenth of an inch long and semi-transparent

FIGURE 8.—Mature, or well-grown, larva of the webbing clothes moth. Larvae differ in size, but seldom exceed half an inch in length. They are chalk white, with a brown or blackish head. Enlarged 7½ diameters

steam-heated apartments. The insect does no harm in the pupal stage; it merely transforms from the larva to the adult, or moth.

DURATION OF DEVELOPMENT

As will have been gathered from the foregoing, each clothes moth passes through four stages in its life. The adult moth lays the eggs from which the larvae hatch. The larva, in turn, spins a cocoon and changes to the pupa, which finally develops into the adult, or sexually mature moth. The total time required for the insect to pass through this so-called "life cycle" is of unusual interest and importance to furniture owners who are attempting to solve the

FIGURE 9.—Cocoon of webbing clothes moth, sectioned to show the well-grown larva about to transform to the pupal stage. Natural length of larva about one-half inch. Enlarged 6 diameters

FIGURE 10.—Cocoon of webbing clothes moth, sectioned to show a pupa. It is from this pupa that the moth develops and emerges. Observe pellets of frass (p. 22) which the larva wove into the cocoon. Enlarged 6 diameters

problem of responsibility for infestation. It is unfortunate that there is not more uniformity in the developmental periods, for such uniformity would simplify problems involving responsibility. The following definite records of development of individual moths are taken from the files of the Department of Agriculture.

The shortest period of development recorded lasted 55 days, from the day the egg was laid to the day the moth left the pupa. This egg was laid January 24, 1924, the larva hatched from the egg January 30, and the adult emerged from the pupa on March 20. This specimen was held in an incubator at an even temperature of 85° F. Another individual developed from an egg laid January

31, 1924, and became an adult July 24, or 175 days later. Many other moths developing from eggs laid between January 24 and January 31, 1924, held at the same even temperature of 85° F., and fed the same food, matured as adults at intervals ranging between 55 and 175 days after the laying of the eggs.

The longest period of development known to the writers extended from August 24, 1922, when the egg was laid, to June 12, 1926, when the adult emerged, that is, nearly four years. Many other eggs, laid in August, 1922, developed into moths at various times during the interval from March to August, inclusive, 1923. The interesting specimen just mentioned as hatching from the egg on August 24, 1922, and maturing as a moth in June, 1926, fed voraciously until winter set in, and fed again during the summer of 1923, but by September 14, 1923, had protected itself by building a cocoon called by the writers a "resting cocoon." In this cocoon it remained quiet, without food, until January 15, 1926. When examined at that time, the larva was found to be still in the cocoon. It was not examined again until February 5, when it was found to have left the cocoon and to be feeding normally and giving every indication of being thoroughly healthy.

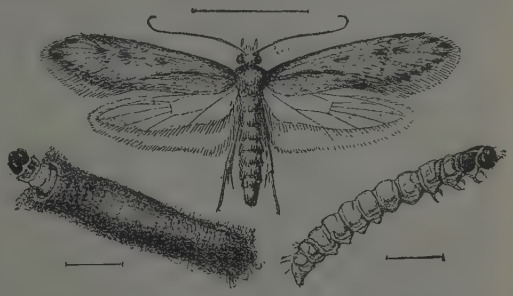

FIGURE 11.—The case-making clothes moth: Upper, Adult moth, × 6; right, larva, × 6; left, larva partially concealed in the case (Riley), × 6. Observe the dark spots on the buff-colored fore wings; these distinguish the adult of the case-making clothes moth from that of the webbing clothes moth, the wings of which are uniformly buff colored

To those interested in and concerned with the biology of clothes moths, the variations in the length of the life cycle from 55 days to nearly 4 years is of practical interest. Special interest centers in the minimum period for development and in the ability of the worms to spin for themselves cocoons in which they remain inactive.

Even when given the best of food conditions and normal humidity, most individuals reared by the writers required from 65 to 90 days as a minimum for development when entire development occurred during the summer under normal conditions. If eggs are laid in August, most of them will become adults in the course of the following April, May, June, and July. In protecting furniture the minimum period for development must be considered as most important.

The peculiar ability of the larva to go into a resting cocoon and refrain from eating for long intervals results in tremendous variations in the period of development that seem entirely independent of conditions of food, temperature, and humidity. This resting, or dormant period, may be very short; 8 to 11 months is not unusually long, but the one of at least 29 months referred to above is the longest observed by the writers. Not many larvae of a total number kept under observation become quiescent under conditions of warmth

and humidity, when their companions are feeding actively. This state of quiescence may be abruptly terminated by a condition that irritates or disturbs the larva.

THE FOOD OF CLOTHES MOTHS

NORMAL FOOD

It is well known that the larvae of clothes moths feed on materials of animal origin, such as hair, fur, wool, and feathers, and on all

FIGURE 12.—Two case-making clothes-moth larvae, mostly hidden within their portable cases. These cases are carried about by the larvae wherever they go. Since it has six legs on the three body segments just back of the head, the larva has no difficulty in pulling the case about. When feeding (in this instance, upon a feather), the larva crawls partly out of the case, as shown. When disturbed, the larva withdraws quickly into the case, and the flaps at the exit are quickly pulled shut, and no one would suspect that a live insect was within. Enlarged 6 diameters

things into the manufacture of which these enter. Other animal products less often thought of as food for moths, but often very important from the standpoint of keeping alive infestations in buildings, are casein, dried excretions from animals, and the desiccated bodies of all kinds of insects and of bats, birds, rats, and mice. Foods sometimes not thought of by the housewife are piano felts, and the fur of pets and the woolen lint lodged in floor cracks, behind baseboards, or carried by air currents to inaccessible places in partitions.

As previously stated, the adult clothes moths take no food during their brief lifetime; in fact, their mouth parts are so imperfectly developed that eating is impossible.

MATERIALS NOT USED AS FOOD

Moth larvae do not feed upon materials of vegetable origin. Linen, cotton, and rayon goods, wrapping paper, and vegetable fibers are not eaten. Natural silk, although not vegetable, is seldom eaten. In

FIGURE 13.—A dish (natural size) showing many cases of the case-making clothes moth, together with all that is left of a handful of feathers taken from a cushion of a divan. This cushion had been reduced to a mass of dead insects, moth excrement, and feather ribs

rare instances the larvae may eat holes in paper or in cotton and linen goods, but this, when it occurs, usually results from excessive infestation in close quarters, or the cutting of the goods by the larva that it may obtain bits of material to build into its cocoon. For all practical purposes moth larvae do not feed upon vegetable products.

THE PARTS OF UPHOLSTERED FURNITURE EATEN BY MOTH LARVAE

In upholstered furniture the larvae of clothes moths feed upon the woolen fibers in covers (figs. 1, 2, 3), the feathers in cushions (fig. 13) and pads, and to a limited extent upon hair fillings (fig. 14).

In advanced cases of infestation the dead moths and larvae resulting from the high rate of mortality suffered by moth colonies are important sources of food.

IMMUNITY OF VEGETABLE MATERIALS USED FOR UPHOLSTERING

Contrary to the belief of many, vegetable products used in upholstering furniture are not fed upon by larvae of the clothes moth. The most commonly used vegetable products are cotton batting, burlap, cotton and linen fabrics, Spanish moss, flax straw or tow, palm fiber, and sea moss. Whenever any of these products, used for padding the furniture, come in direct contact with a woolen cover, the larvae take advantage of their more or less porous nature

FIGURE 14.—End of a leather-covered couch, with end pieces laid back to show moth webbing in the curled hair and the many moth cocoons attached to the inner surface of the leather. Each cocoon is about half an inch in length. Such a piece of furniture may produce many moth millers

to secure a safe retreat in which to molt and rest when not feeding upon the wool in the cover.

Under such circumstances the worms may fill the moss, tow, or other material so full of their webs and excrement and so many dead larvae may be found in it as to make it appear as a food of the larvae. (Fig. 15.) If bales of any of the vegetable materials here mentioned were set in a warehouse by themselves they would never attract clothes moths.

HOW MOTHS GET INTO FURNITURE

Upholstered furniture, when built by reputable firms, is free from infestation by moths. Great care is taken to use only insect-free materials, and the product is above suspicion. Since clothes moths are universal pests, furniture with woolen covers is likely to be-

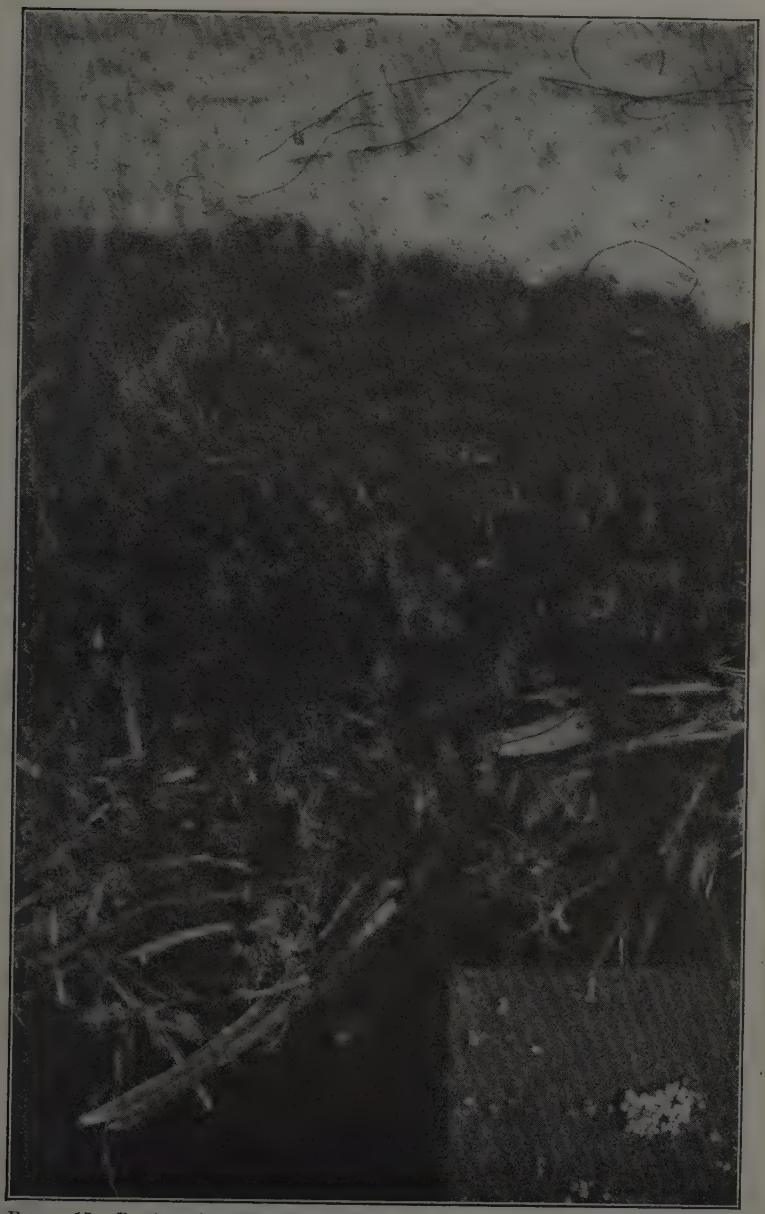

FIGURE 15.—Portion of pad from back of upholstered chair. Observe the layer of cotton batting, the Spanish moss, and tow. Where the moss and tow come in contact with the woolen cover they are filled with the excrement and webbing of clothes-moth larvae. Covers in contact with moss, hair, tow, palm fiber, or any other similar material, are apt to become damaged. The insert shows the gritty or sandlike pellets of larval excrement, magnified about 2 diameters

come infested if it is exposed in any room where moths are present. Although moth larvae crawl, it is not believed that they crawl into upholstered furniture from other house furnishings. Infestation comes about from the eggs laid by the adult moth or miller, which finds its way to the furniture. The female moth, in seeking a dark, secluded place, may crawl between the cushions and the back or sides of the chair or divan, and thus find herself in the open spaces usually present at the sides and back of furniture. In these spaces, or among the springs, she finds a very satisfactory, protected place

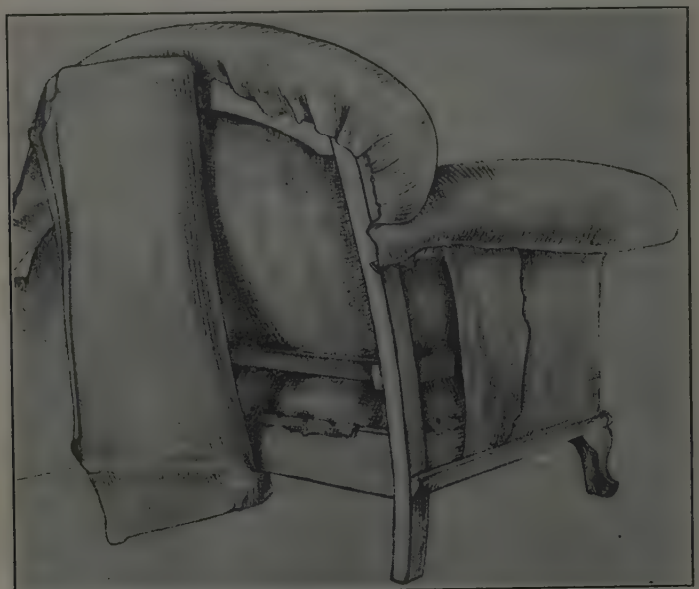

FIGURE 16.—Overstuffed furniture of the type illustrated here is ideal for the development of clothes moths. The newly hatched larvae crawl into the furniture at various points where the covering is tacked on, or even by forcing their way through the covering itself, or through the spaces between bottom, sides, and back. Once inside, the insect finds in the abundant food material and the large open spaces of the sides and back and about the spring coils conditions permitting increase, and generation after generation can multiply without any adult moths leaving the furniture. If larvae spin up for transformation between the pieces of covering, the adults may succeed in leaving the chair; large numbers lay their eggs within and about the open spaces, from which the developing worms may migrate

in which to lay her eggs unseen and unmolested by brush or vacuum cleaner. (Figs. 16 and 17.)

More often the female moth deposits her eggs here and there on the cover. Figure 18 is a diagrammatic drawing indicating how she uses the telescopic ovipositor to place eggs down among the fibers of the tufts of pile. The moth may also tuck her eggs into the seams and the crevices formed by the edges of the pieces of the cover where they are tacked to the frame. Unless the bottom of the furniture is thoroughly ceiled with fabric the moth may enter at openings where the legs join the frame, and lay eggs at will among the springs.

FIGURE 17.—Type of construction which will assist in preventing injury to furniture resulting from feeding of moths from beneath the cover. Observe that the chair has been formed with a stout cotton cover over which the outer cover will be applied; observe also the use of cotton batting at the front and everywhere beneath the cotton or inner cover. Although moths might get into the spaces about the springs and from there pass through the burlap covering them, into the moss or hair, they can not eat their way through the unbroken layers of cotton batting

FIGURE 18.—Clothes moths often lay eggs in the pile of the furniture cover, as indicated in this drawing. The young larvae on hatching either force their way into the furniture through the warp of the cover, or enter it through points even more accessible to them. Of course many will feed on the pile tufts themselves if they are not molested by brushing or house cleaning. Enlarged 25 diameters

TWO METHODS OF ATTACK UPON WOOLEN COVERS

Once the eggs have been laid, they hatch within a very few days. (P. 6.) The newly hatched larvae (fig. 7) are capable of squeezing through incredibly small openings. They are very active, and crawl readily in an attempt to get away from the brightest light. In seeking a suitable place to feed they either spin their first webs in the very inconspicuous spaces between the rows of pile and against the upper side of the warp, or they are successful in working their way into the inside of the furniture by way of the seams, the spaces between the cushions and the sides or the back, or, in some instances, through the mesh of the warp itself. And, according to whether they stay on the outside or get beneath the cover, their feeding results in two types of injury, known respectively as "surface feeding" and "feeding from within" and beneath the cover.

SURFACE FEEDING

In the case of surface feeding the larvae remain on the outside of the covers, where they can be seen and reached. They crawl down between the rows of pile and there build elongated silken tubes of a whitish color, which they use as passageways. Although they attempt to conceal both themselves and these tubes by spinning into the webs some of the remnants of the fabric upon which they feed, they are not entirely successful; during early larval life the tubes retain their whitish color and a careful search reveals them. Figure 19 illustrates numbers of tubes spun on the exposed underside of a mohair warp. The tubes in mohair covers usually follow the rows of pile, as indicated in Figure 21. Other views of surface feeding are shown in Figures 2, 3, and 20. If one were to cut across the cover itself the larval and pupal cocoons might be revealed clearly as in the diagrammatic sketch shown in Figure 22 and in the actual photograph presented in Figure 23. Sometimes as larvae become older they build their feeding tubes over the top of the pile, as is shown in Figures 2 and 3. Surface feeding occurs chiefly on the portions of the cover that are turned against the wall, are behind pillows, or in other shaded spots, or anywhere on the furniture, provided the room is seldom used or is closed for the summer or the season.

When mohair has been injured by surface feeding the back side of it appears normal. The pile is eaten off just above the warp. An examination under a hand lens will reveal whether or not the injury is the result of surface feeding.

FEEDING FROM BELOW THE COVER

While surface feeding, or feeding on the outer side of the furniture cover, is always evident to anybody who will look for it carefully, feeding from beneath the cover is of a most insidious nature. Like a thief, the larva works unseen and usually unsuspected. It is not until the pile begins to fall out in irregular patches when the furniture is brushed or otherwise cleaned that the owner suspects that something is wrong. In Figure 1 is shown the usual form of injury. The pile falls out as indicated on the front, beneath the cushion, and on the side near the bottom. As the vegetable warp

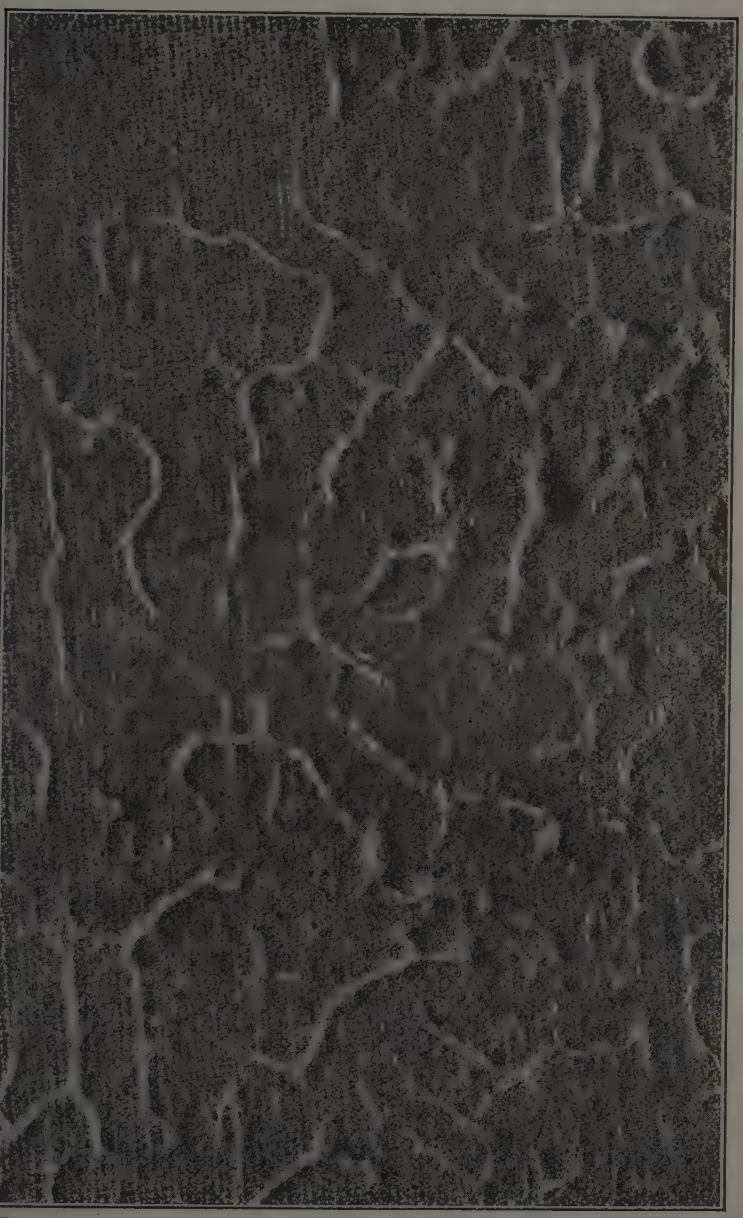

FIGURE 19.—Many feeding tubes, natural size, built by the larvae of the webbing clothes moth on the back of mohair from the side of a chair built as indicated in Figure 16. The larvae crawl back and forth through these tubes, protruding their heads to feed when they wish upon the wool in the cover, but more often extending the tubes as they need more food

FIGURE 20.—Side chair, the seat covering of which is damaged by surface feeding by larvae of the webbing clothes moth. Furniture upholstered with woolen covers is likely to be injured by surface feeding, especially if covered with slip covers and left standing in living rooms, or if left unprotected in storage

FIGURE 21.—Portion of cover of the chair shown in Figure 20, photographed natural size, to show the usual indications of surface feeding which is still, for the most part, confined to the spaces between the rows of pile. Notice that the larvae build their white silken tubes between the rows of pile. From these tubes the larvae browse upon the threads of the pile, cutting them off above the warp foundation

of mohairs is usually different in color from that of the woolen pile, the furniture assumes a spotted appearance and its aesthetic value is destroyed.

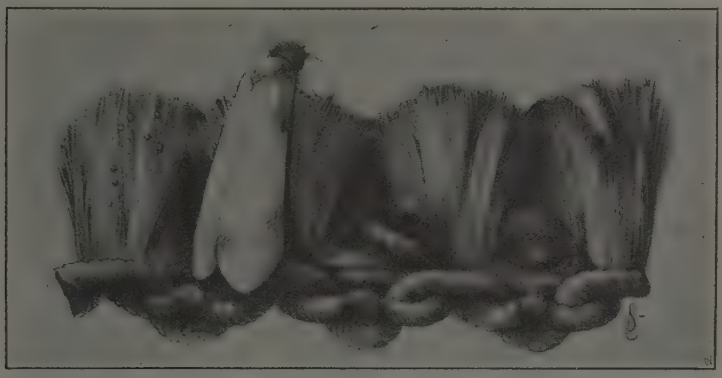

FIGURE 22.—Injury to carpet by the webbing clothes moth: Eggs faintly shown against tuft of mohair pile at left; adult moth on next tuft, to the right of which, below, is shown a larva eating at base of the third tuft; in the last space is a cocoon with the end cut away to expose the pupa within; a larva is shown crawling over the top of tuft at extreme right. Enlarged 5 diameters

What actually happens is that wherever the larvae gain access to the underside of the woolen cover they begin to eat the woolen threads where they pass beneath the warp, which, being of vegetable

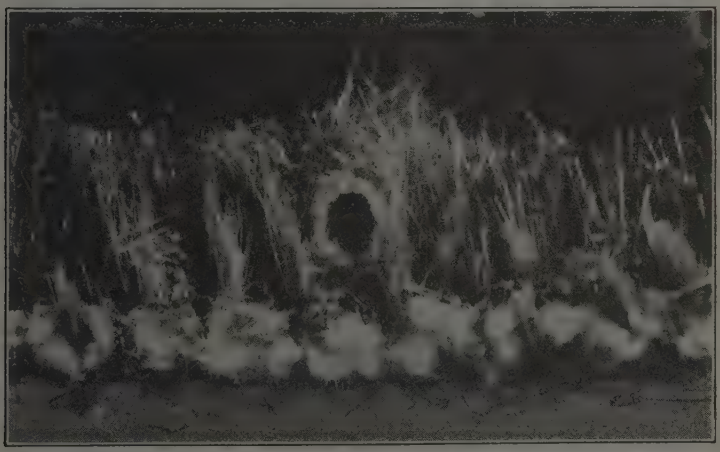

FIGURE 23.—Cross section of mohair cover, revealing a feeding tube of a larva of the webbing clothes moth. These tubes are usually close to the warp when the larvae are very young, but as the larvae grow older the tubes extend everywhere and are sometimes even built on the surface of the mohair, as shown in Figures 2 and 3. Enlarged about 10 diameters

origin, is not eaten. In Figures 24 and 25 is shown in a diagrammatic way how the worms form their tunnels beneath the cover and cut the woolen threads so that the tufts of pile fall out.

When woolen mohair is stretched over an opening, as at the sides and back of certain types of upholstered furniture, the moth larvae

FIGURE 24.—Cross section of a portion of overstuffed furniture covered with mohair. This is a diagrammatic drawing showing that injury through feeding from beneath the cover is confined chiefly to spots where the cotton, shown as white areas at each side beneath the mohair, is broken or carelessly applied over the curled hair or Spanish moss. In this illustration the moss touches the mohair in the central area. Clothes-moth larvae build their silken tubes in the moss and crawl up to the mohair covering when they wish to feed. Notice how the two worms shown have cut the woolen threads of the pile where they pass beneath the foundation warp. The condition shown in Figure 25 results. Enlarged 2 diameters

have an excellent opportunity to build their feeding tubes at will over a flat surface. In Figure 19 is shown on the natural scale an array of these tubes. Each tube, which in cross section would appear much as in Figures 22 and 23, may shelter a growing worm

FIGURE 25.—The same covering as shown in Figure 24, after it has been thoroughly brushed or cleaned by vacuum. Notice that the pile has fallen out wherever it has been cut from beneath. It is the development of these bare spots in the furniture covers that affects the aesthetic value of the furniture more than the actual loss of materials eaten. Enlarged 2 diameters

which makes an opening in the tube when and where it will in order that it may browse upon the woolen threads.

THE VALUE OF COTTON BATTING IN PREVENTING FEEDING FROM BENEATH THE COVERS

In much upholstered furniture in American dwellings pads of vegetable fibers, such as flax tow, Spanish moss, and palm fiber, and sometimes curled hair, cover the springs of the back and the arms. These pads are then covered with a layer of cotton batting before the fabric cover is applied. It has been found that this layer of cotton batting is of great importance in warding off, or entirely preventing, much of the injury caused by worms feeding beneath the surface. It has been estimated that fully 90 per cent of all well-defined areas of feeding, where cotton backs the cover, are due to faulty workmanship at the factory, and should be directly charged to the upholsterer. For example, in the winged chair shown in Figure 26, feeding by the larvae caused the pile to

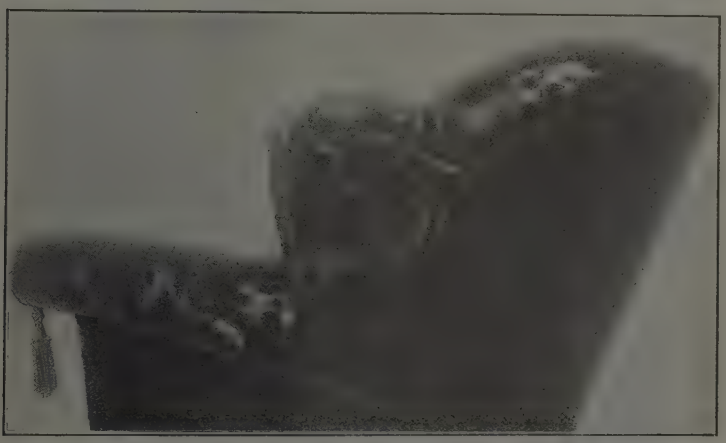

FIGURE 26.—Overstuffed winged chair with bare spots developing at top on back and along outside of arm, where the mohair pile has fallen out. The damage is caused by moths, attacking from beneath the cover. Compare the location of the injury with the places where cotton is lacking in Figure 27

fall out at spots on the top of the back and on the outer side of the arm. In the companion photograph of the same chair, shown in Figure 27, the mohair covers have been laid back to show that at the top, in pulling the layer of cotton batting, the workman who covered the chair broke off a handful of cotton and failed to remedy his carelessness. On the arm the two layers of cotton batting are improperly overlapped. In each case the vegetable filling, in which the larvae like to nest when not feeding on the cover, was allowed to come in direct contact with the cover itself, thus establishing a paradise for the larvae. (Fig. 15.) Figure 28 in like manner shows how carelessness in construction in six distinct places may have resulted in loss to the purchaser. Sometimes very young larvae of the clothes moth can push their way through a woolen cover that is backed with a layer of cotton batting, but even if they succeed they usually die before reaching maturity. If, however, there is

no cotton or other material to stop them they find conditions ideal for feeding.

THE DEVELOPMENT OF SUCCESSIVE GENERATIONS WITHIN THE FURNITURE

The adult moths are very soft and fragile, and, since they can not eat holes themselves, those that mature within the furniture from young worms that have worked their way in find themselves in the darkened open areas at the sides, back, or among the springs, according to where the larva happened to spin its cocoon. Being thus confined is, however, no obstacle to mating and egg laying, and the young larvae upon hatching find an abundance of food in places where they are not molested by housekeeping activities. It thus

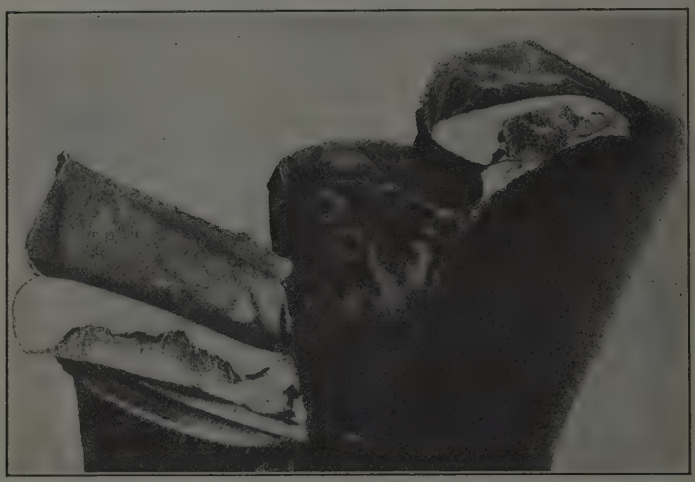

FIGURE 27.—The chair shown in Figure 26, with the covers turned back at points of injury. Notice that the injury to cover is over spots where the cotton is lacking or faultily applied, thus allowing the moss or hair in which moth larvae like to nest to come in contact with the mohair cover

happens that moths can breed generation after generation within many types of upholstered furniture without being seen from the outside. When infestations become excessive, well-grown white larvae may become restless, and in seeking new pastures may crawl to the outside and be seen.

FRASS

In handling or opening furniture infested by clothes moths many tiny pellets drop to the floor. They are gritty and hard, and look and, when stepped upon, feel like fine sand. They often fill the furniture stuffings, as is shown in the insert to Figure 15. They are often called eggs of the moth, but in reality are only excrement or frass of the moth larvae, and can in themselves cause no harm. Their color is apt to be similar to that of the food upon which the worms have fed. The eggs of clothes moths are very fragile, soft, and white, and very unlike the larval frass.

CONTROL

Fortunately there are a number of ways to combat moths successfully in upholstered furniture—ways which are not expensive and which permit the enjoyment of any type of cover that satisfies the demand of the owner for beauty, durability, and style. Preventive and remedial measures should be considered.

FIGURE 28.—Mohair-covered chair, with cover turned back to show defects in cotton batting (1, 2, 3, 4, 5, and 6) which correspond to external bare spots on the cover, of the same character as those shown in Figure 26. Notice the webs of larvae on inside of mohair at bottom. This was an old and much neglected and abused chair

PREVENTIVE MEASURES

COVERS OF LEATHER, SILK, COTTON, LINEN, OR RAYON

The problem of moths in upholstered furniture can be eliminated for all practical purposes, from the very start, by the use of covers of leather, silk, cotton, linen, or rayon, or fabrics combining these fibers, such as some brocades and tapestries. If cushions filled with feathers are used with these covers there is always the possibility of damage to the feathers themselves (fig. 13), but instances of damage by moths to such cushions are rare.

TREATING WOOLEN COVERS WITH MOTH-PROOFING SOLUTIONS

Leading manufacturers of mohair fabrics are now treating their product with solutions said to render the fabric so treated immune to attack by moths. Although the Department of Agriculture has in its laboratory work found no solution that will permanently and absolutely render any fabric moth proof, the results of this work indicate that the better solutions now available can, if properly applied, impart a resistance that, while not absolute, is of sufficient value to be of practical importance. It is possible when buying furniture with woolen covers to select only such pieces as have covers that have been treated at the factory. Some of these carry guarantees of immunity for several years; and where guarantees are given it is wise to take advantage of them.

UNBROKEN LAYERS OF COTTON BATTING

If the furniture under consideration has a woolen cover backed by a layer of cotton batting between it and the upholstering fibers (such as tow, moss, or hair), the salesman should assure the buyer that in building the furniture the upholsterer has not broken, torn, or improperly applied the cotton layer so as to permit the hair, tow, moss, or other fiber to come in direct contact with the cover. The manufacturer or retailer should be held directly responsible for damage resulting from improperly applied layers of cotton.

CUSHIONS OF SPRINGS AND COTTON BENEATH THE COVERS

Cushions consisting of springs sewed in a linen or cotton cover and surrounded by a layer of cotton batting between the springs and the cover are never infested by moths on the inside, as there is nothing in such a cushion for moths to feed upon. Other cushions built up with a central set of springs covered with linen, surrounded next by a layer of black curled hair, and finally by a linen-covered cushion of feathers or down before the cover is applied, or, instead of the feather cushion, a layer of cotton batting between hair and cover (fig. 29), are practically immune to attack by moths on the inside, provided the hair and feathers were properly sterilized before the cushion was made up.

FUMIGATION BEFORE DELIVERY

A large number of furniture dealers and warehousemen have now provided themselves with fumigating rooms or vaults (figs. 30, 31, 32) in which they can treat returned or secondhand pieces, or pieces intrusted to them for a period of storage. Treatments to kill insects in furniture, either by heat or fumigation, might well be insisted upon as a condition of purchase in case a person wishes to go to the extreme in satisfying himself that no infestation by moths is present in the furniture at the time of purchase. This service will undoubtedly be given by the manufacturer or retailer at a just price should a request for it be made.

Very effective fumigating rooms can be made of two thicknesses of tongue-and-groove boards with building paper between. Care should

be taken to provide all rooms with gas-tight doors. Rooms must be so constructed that the gas used can not leak out at the union of walls with ceiling or floor or about the door. Doors must fit tightly. If furniture is to be fumigated during cold weather, it comes into the warehouse well chilled and should be warmed before fumigation begins. For this reason the fumigating room should be equipped with a heating unit of some sort. Never fumigate with an inflammable and explosive gas when the heat is turned on, or until after the heating equipment has had an opportunity to cool.

HOME CONDITIONS

Contrary to the belief of very many persons, clothes moths are present in nearly every dwelling. As shown on page 10, they find

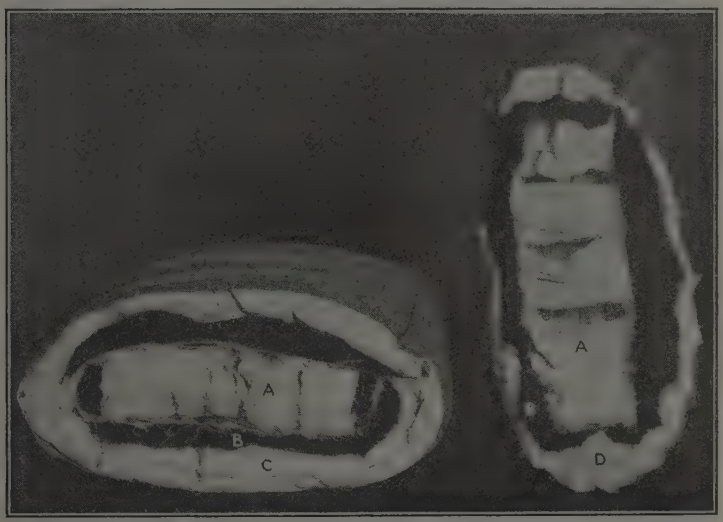

FIGURE 29.—Cross sections of two types of cushions: A, Springs inclosed with linen or cotton; B, curled hair; C, pad of feathers or down inclosed in linen cover; D, layer of cotton batting

food for development and may be present even though no garments, rugs, etc., are found injured by them. In addition to the sources of food listed on page 10, there is the woolen lint that collects in neglected vacuum-cleaner bags or is drawn in and deposited by air currents in the flues of hot-air furnaces. Much furniture is infested by moths that have developed somewhere about the house before flying to the furniture. If a house is thought to be generally infested it is wise to have it fumigated as a whole. This procedure is an excellent way of protecting furniture and all susceptible furnishings.

SLIP COVERS

Much injury by moths can be prevented by the judicious use of slip covers. The unwise use of slip covers favors injury by the process

known as surface feeding (p. 16). In seeking a quiet place the adult moth crawls up beneath slip covers and lays her eggs. The larvae hatching from these eggs find sheltered, darkened spots for uninterrupted feeding, and if left unmolested may seriously deface covers in the course of a summer. Slip covers should be removed at varying intervals, according to circumstances, and the pile thoroughly brushed or otherwise cleaned to dislodge or kill moths working in it (p. 18).

REMEDIAL MEASURES

Remedial measures consist in treatments that must be given after purchase to kill moths that may get into the furniture. There are a number of excellent methods for freeing upholstered pieces of all

FIGURE 30.—A fumigating room installed by the Bureau of Entomology. This room is 8 by 10 by 6 feet, of steel construction, equipped with an exhaust fan connected with a galvanized-iron pipe through which the fumigant is blown to the roof of the building. The room is installed on the second floor of a 3-story building, and the exhaust pipe runs up the outside of the building. Gas in lethal strength has been held in this room for a number of days. Similar good rooms from the standpoint of tightness and good results can be built of wood, cement, or brick

living moths—fumigation, heat, cold, and a combination of fumigation or heat and the application of a dependable moth-proofing solution.

FREQUENT BRUSHING AND TREATING WITH VACUUM

Most important in eliminating the development of surface feeding is frequent brushing and treating with vacuum. If furniture covers are not moth-proofed they should be thoroughly gone over by one of these methods at least once a week to dislodge and crush eggs and kill young larvae of the moth. This careful attention will prevent surface feeding. Surface feeding is always the result of lack of care on the part of the housewife, who alone is responsible for such injury. Surface feeding on the pile is out where it can be seen by careful scrutiny.

FIGURE 31.—Furniture being carried into a room equipped for heating furniture to such a degree that all moth life is killed. Several storage firms are enthusiastic over the treatment with heat, and offer this control service to the public

FIGURE 32.—A rubberized bag into which upholstered furniture can be placed after treatment with paradichlorobenzene crystals or with certain fumigants. The man in the picture is attaching a can of carbon tetrachloride to the upper valve of the bag. Such bags, or shellacked corrugated cartons, are best used for treatment with paradichlorobenzene

FUMIGATION

Fumigation consists in subjecting furniture in inclosures, such as tight rooms or vaults (figs. 30, 31, 32) to gases or vapors that penetrate the upholstering and kill all forms of moth life, including destruction of the eggs. The fumigants most commonly used at the present time (January, 1931) are, in their alphabetical order, carbon-disulphide, chloropicrin, the ethylene dichloride-carbon tetrachloride mixture, ethylene oxide, alone or in combination with carbon dioxide, hydrocyanic-acid gas, naphthalene, and paradichlorobenzene.

Each of this array of available fumigants has some disadvantage or advantage, and which fumigant is to be used will depend upon circumstances. Some, like hydrocyanic-acid gas or chloropicrin, are very toxic to human beings; others, like carbon disulphide, while effective, are explosive and inflammable in the presence of fire in any form. If the service of a professional fumigator is obtained through cooperation with a dependable local storage warehouse for household goods, or with a fumigating company, excellent results can be made to follow the use of any of the above mentioned fumigants, as they will presumably be handled by persons thoroughly familiar with their characteristics. In general, such firms are very willing to give information regarding any of the fumigants, with directions for application.

But for the average householder who, because of some such reason as isolation, is not able to obtain the services of professional fumigators, it is better to depend upon a treatment that can be applied safely and economically at home, even though it is not the best known method of eliminating moths. For home treatment by the housewife the use of paradichlorobenzene is recommended.

PARADICHLOROBENZENE

Paradichlorobenzene is a white crystalline chemical, similar in general appearance to flake naphthalene. If the crystals are finely divided and applied in any manner, such as scattering by hand, over the furniture covers, down round the cushions, especially where the cushions touch the arms and back of the furniture, and even down into the spaces at the sides and back, they evaporate, forming a gas or vapor that is heavier than air. If the vapor can be confined with the piece of furniture long enough and in sufficient concentration, all stages of the moth will be killed.

To assure this concentration, 2 or 3 pounds of the crystals should be well distributed over the covers of a chair, and the furniture immediately wrapped in several old blankets which overlap one another well and more than touch the floor on all sides. Instead of blankets, large rubberized bags (fig. 32) or large shellacked cartons may be used. If, during warm weather, furniture is allowed to stand several days thus treated and wrapped, practically all moths within it will be killed. This is not as good a treatment for the home as fumigation by a professional, but it is safe, easily applied, and reasonably effective if the room temperature is 70° F. or above during the period of treatment. In certain tests made by the writers excellent results were obtained by a 2-day exposure in very warm summer weather.

If a room is to be vacant for several weeks, as during a vacation period, or between seasons at hotels, etc., clothes moths have been very well controlled by wedging all windows and doors, pulling shades, and scattering, over papers spread upon the floor, 8 or 10 pounds of paradichlorobenzene crystals to each room of average size. Although less than a pound of the crystals per 1,000 cubic feet is needed to saturate the atmosphere, there is much leakage from any ordinary house room, and the dosage suggested will provide for continuous evaporation for several weeks. The eyes and nose will smart when a room so treated is first entered. However, the odor of "paradi" is quickly dissipated, and is recognized only with diffi-

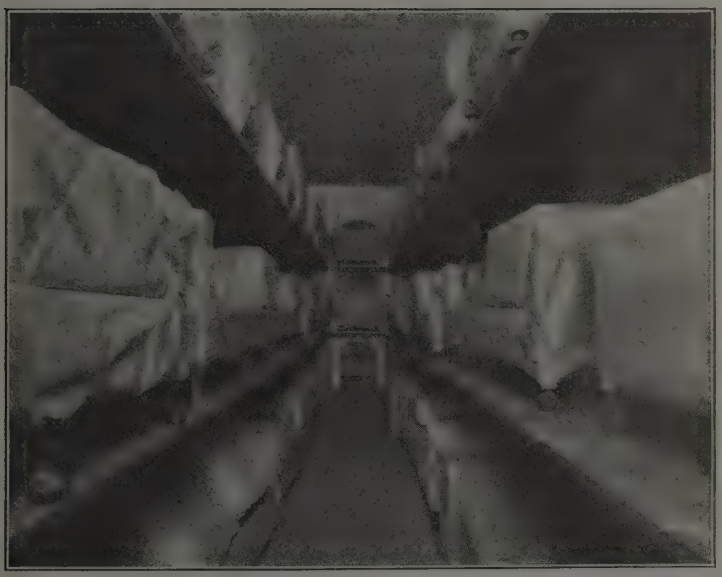

FIGURE 33.—Interior view of a furniture storage room in a modern storage warehouse for household goods. Each piece is wrapped in heavy paper after treatment with paradichlorobenzene or flake naphthalene. Sometimes the crystals are placed beneath the furniture instead of directly on the covers. Do not allow the crystals to stand on the exposed surfaces of the frame

culty after several days of ventilation. Flake naphthalene can be used in the home, but the odor persists longer than that of paradichlorobenzene, and the flakes do not appear to evaporate so rapidly. Only the best grade of paradichlorobenzene crystals should be purchased. They cost in bulk about 14 to 16 cents per pound. Addresses of manufacturers will be furnished by the Bureau of Entomology in case local druggists do not carry a stock. Figure 33 illustrates the excellent manner in which household-goods warehouses protect mohair furniture sent to them for storage. These tight rooms are kept well stocked with "paradi" or flake naphthalene, and in them no injury occurs.

HEAT

The use of heat as a means of killing moths in upholstered furniture is possible, as a rule, only in warehouses equipped with specially constructed rooms (fig. 31) in which the temperature can be raised. Schlossberg found that in such rooms the thermometers outside the furniture should register between 165° and 170° F. through a 5-hour period, to assure the destruction of moths of all stages. Blistering of the wood finish is apt to occur, but the cost of refinishing is relatively slight.

COLD

Placing furniture on porches or the roofs of apartments during zero (Fahrenheit) weather will kill all moths within a few hours after the zero temperatures reach the individual moths. The unfortunate feature of this otherwise excellent control is that zero weather is seldom available at the right time and place.

COMBINATION OF FUMIGATION AND MOTH-PROOFING SERVICES

The great drawback to any effective fumigation of upholstered furniture is that no fumigant is known that will render the treated piece immune to future infestations. As soon as a fumigated or heat-treated piece is exposed in a house where moths exist (as they do in nearly every house, regardless of the owner's belief) it is subject to reinfestation by eggs deposited on its covers by a flying moth.

To meet the need for a prevention of reinfestation after fumigation, a number of moth-proofing solutions are now available. The most effective of them are the fluoride, cinchona-alkaloid, and rotenone solutions. Solutions containing arsenic in any form are not advocated, the use of arsenic in this manner having been disapproved by the American Medical Association. As already stated (p. 24), the laboratory experiments of the Department of Agriculture have indicated that no solution now available will render fabrics absolutely and permanently immune to the feeding of moths. Yet, when the better solutions are properly applied, under pressure, by spraying machines, they impart a resistance of practical value in this respect. So effective are they that moth-proofing services are now available in all large cities through storage warehouses for household goods, dry-cleaning establishments, or through special agencies. In some instances a guarantee against damage by moths for a term of three to five years is given at the time of treatment.

In Figure 34 are shown workmen of a firm specializing in demothing and moth-proofing service applying a moth-proofing solution to furniture in a private home. In Figure 35 is shown the method of applying, under air pressure, an aqueous fluoride solution to a couch covered with woolen tapestry.

CAUTION

Moth-proofing solutions applied to furniture covers are of value only if the covers are thoroughly saturated. Many persons have had unsatisfactory results from applications made at home by spraying the liquid as a mist from pint or quart bottles by means of a finger-

FIGURE 34.—Workmen of a storage warehouse for household goods treating furniture with a moth-proofing solution. This method of treatment is increasingly being applied to furniture in all types of homes

worked sprayer. Even one of the better solutions is ineffective when so applied. If reliance is placed on moth-proofing solutions it is wise to have the solution applied by a power outfit.

FIGURE 35.—Man applying under air pressure an aqueous fluoride solution to a couch covered with wool tapestry. The couch was fumigated before the solution was applied

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE WHEN THIS PUBLICATION WAS LAST PRINTED

Secretary of Agriculture	ARTHUR M. HYDE.
Assistant Secretary	R. W. DUNLAP.
Director of Scientific Work	A. F. WOODS.
Director of Regulatory Work	WALTER G. CAMPBELL.
Director of Extension Work	C. W. WARBURTON.
Director of Personnel and Business Administration.	W. W. STOCKBERGER.
Director of Information	M. S. EISENHOWER.
Solicitor	E. L. MARSHALL.
Weather Bureau	CHARLES F. MARVIN, *Chief.*
Bureau of Animal Industry	JOHN R. MOHLER, *Chief.*
Bureau of Dairy Industry	O. E. REED, *Chief.*
Bureau of Plant Industry	WILLIAM A. TAYLOR, *Chief.*
Forest Service	R. Y. STUART, *Chief.*
Bureau of Chemistry and Soils	H. G. KNIGHT, *Chief.*
Bureau of Entomology	C. L. MARLATT, *Chief.*
Bureau of Biological Survey	PAUL G. REDINGTON, *Chief.*
Bureau of Public Roads	THOMAS H. MACDONALD, *Chief.*
Bureau of Agricultural Economics	NILS A. OLSEN, *Chief.*
Bureau of Home Economics	LOUISE STANLEY, *Chief.*
Plant Quarantine and Control Administration	LEE A. STRONG, *Chief.*
Grain Futures Administration	J. W. T. DUVEL, *Chief.*
Food and Drug Administration	WALTER G. CAMPBELL, *Director of Regulatory Work, in Charge.*
Office of Experiment Stations	————, *Chief.*
Office of Cooperative Extension Work	C. B. SMITH, *Chief.*
Library	CLARIBEL R. BARNETT, *Librarian.*

U. S. GOVERNMENT PRINTING OFFICE: 1931

For sale by the Superintendent of Documents, Washington, D. C. - - - Price, 10 cents